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Spread and Intensification of Western Larch Dwarf Mistletoe (*Arceuthobium laricis*) Following Removal of an Infected Overstory and (or) Precommercial Thinning: Twelve-Year Remeasurements.

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Introduction

This report describes results of the 12-year remeasurement of plots established on the Flathead Indian Reservation in Montana (Taylor, et. al. 1993) in order to:

1. quantify the spread and intensification of larch dwarf mistletoe (*Arceuthobium laricis* (Piper) St. John) in western larch (*Larix occidentalis* Nutt.) regeneration following:
   a. overstory removal combined with precommercial thinning,
   b. overstory removal only,
   c. precommercial thinning only,
   d. no overstory removal or precommercial thinning;
2. quantify growth impacts of dwarf mistletoe on western larch due to the above treatments;
3. provide a visual demonstration of the treatment effects on stand growth and development; and
4. validate the dwarf mistletoe model extension of the Forest Vegetation Simulator.

Four replicates (plots) were installed in 1991 for each of the four treatments. Remeasurements were originally scheduled on a five year cycle, but ten-year remeasurements were postponed due to staffing changes. Taylor et al. (1993) and Taylor and Marsden (1997) reported on study objectives, plot establishment, baseline data collection, and 5-year remeasurements.

Methods

Twelve-year data were collected in July and September, 2003, and included the following for all live, understory crop trees:

- stem diameter at breast height (DBH);
- total tree height;
- height from base of tree to bottom of live crown;
- Hawksworth (1977) dwarf mistletoe rating (DMR) for the lower, middle, and upper thirds of the live crown;
- crown class (suppressed, intermediate, codominant, or dominant);
- up to three additional damage-agents such as foliar fungi or snow damage; and
- height of the highest and lowest live mistletoe infections (collected for first time in 2003).

Trees dead since the previous remeasurement were noted and cause-of-death determined if possible. Dead trees were not included in analyses.

Analysis of variance (ANOVA) was used to compare plot means for DMR, DMI (tree ratings averaged over infected trees only), height, and DBH between plot treatments: overstory removal vs. no overstory removal, thinning vs. no thinning, and the interaction of overstory removal and thinning. Treatments were applied at the plot level and 1991 plot means were used as covariates when covariates were used. These covariates adjusted means so treatments started with the same factor rating.

Results and Discussion

A total of 1,237 understory trees were tagged and measured when plots were installed in 1991. Of these, 1,186 were remeasured in 1996 (51 dead or missing) and 1,118 were remeasured in 2003 (116 dead or missing and 3 not used in analyses). Cause-of-mortality was difficult to determine in many instances since interactions between multiple factors affected any given tree. Suppression, dwarf mistletoe infection, and (or) Armillaria root disease were variously implicated. Several trees were not located and some non-larch species, particularly subalpine fir, had been harvested as Christmas trees.

Treatment differences are non-significant for plot means as measured (Table 1). With addition of covariates, DMR, height, and DBH are all statistically significant ($P \leq 0.1$). The covariate reduced the error about the means more than it changed the means.

Spread and intensification of larch dwarf mistletoe was least in nonthinned plots with no overstory removal, but greatest in thinned plots with no overstory removal over the first 12 years of this study (Figures 1 & 2). While there was no change in the percentage of larch infected in the nonthinned plots with no overstory removal, infection on the thinned plots with no overstory removal increased 16 % (Table 1). Increases in percent larch infected on the plots with overstory removal were 11 % on thinned plots and 8% on nonthinned plots. The DMR for nonthinned plots with no overstory removal only increased an average 0.4, while other treatments increased at least one full DMR class.

Average DMR was significantly higher in the thinned versus nonthinned plots where the overstory was not removed (Table 1). The 2003 adjusted ANOVA for DMR which included a covariate - plot mean DMR for larch in 1991 - showed that the interaction of overstory removal and thinning was significant to $P = 0.1$, while thinning itself was significant to $P = 0.01$ and overstory removal was insignificant ($P = 0.28$). Twelve years after treatment, thinning had a greater affect on DMR than overstory removal (Figure 2).

Tree height was significantly greater in plots that were thinned with overstory removal than in thinned and nonthinned plots without overstory removal (Table 1). Average height was not significant in nonthinned plots with overstory removal compared to other treatments. The 2003

adjusted ANOVA for height, which included the covariate plot mean height for larch in 1991, showed that overstory removal was highly significant (P = 0.01), thinning was significant (P = 0.1), and the interaction between logging and thinning was significant (P = 0.06). Overstory removal appeared to be more important than thinning in regards to tree height 12 years after treatment (Figure 3).

Average DBH was significantly greater on thinned plots with overstory removal compared to other treatments (Table 1). The 2003 adjusted ANOVA for DBH, which included the covariate plot mean DBH for larch in 1991, showed that overstory removal and thinning were each highly significant (P < 0.001) and the interaction of overstory removal and thinning was significant (P = 0.02).

Table 1. Dwarf mistletoe infection and host data following application of treatments in 1991 and remeasurements in 1996 and 2003. For 2003 adjusted-means, values followed by the same letter are not significantly different (p=.05).

Year	Treatment	All species		Western larch					
		No.	% infected	No. (% all spp.)	% infected	Avg. DMR	Avg. DMI	Avg. Height	Avg. DBH
1991	Overstory removal & PCT	352	63	276 (78)	74	1.0	1.3	11.2	0.9
	Overstory removal only	322	57	249 (77)	69	0.9	1.3	12.2	1.1
	PCT only	279	59	221 (79)	74	1.1	1.4	13.5	1.1
	No treatment	284	50	210 (74)	64	1.0	1.1	13.2	1.2
1996	Overstory removal & PCT	331	67	270 (82)	78	1.3	1.7	16.7	2.0
	Overstory removal only	304	58	244 (80)	67	1.1	1.6	16.7	1.8
	PCT only	274	70	219 (80)	89	1.8	2.0	18.3	2.0
	No treatment	277	56	207 (75)	69	1.2	1.7	18.9	1.9
2003 (means as measured)	Overstory removal & PCT	320	76	267 (83)	85	2.1	2.4	25.4	3.3
	Overstory removal only	283	69	237 (84)	77	1.8	2.2	22.4	2.7
	PCT only	256	74	204 (80)	90	2.3	2.6	22.6	2.7
	No treatment	259	51	196 (76)	64	1.4	1.9	22.8	2.5
2003 (means adjusted *)	Overstory removal & PCT	320	76	267 (83)	85	2.1 a b	2.4 a	27.4 b	3.6 b
	Overstory removal only	283	69	237 (84)	77	1.9 a b	2.2 a	22.8 a b	2.7 a
	PCT only	256	74	204 (80)	90	2.2b	2.5 a	21.2 a	2.6 a
	No treatment	259	51	196 (76)	64	1.4 a	2.1 a	21.7 a	2.3 a
R Squared (correlation of the 2003 means with the 1991 means)						0.82	0.72	0.81	0.93

Note: Columns containing "No." in heading show combined number of trees for all four plots with the particular treatment. All other values in the columns are means of the plot means for each factor.
PCT=Precommercial Thin.
* Means adjusted for the covariate (1991 means).

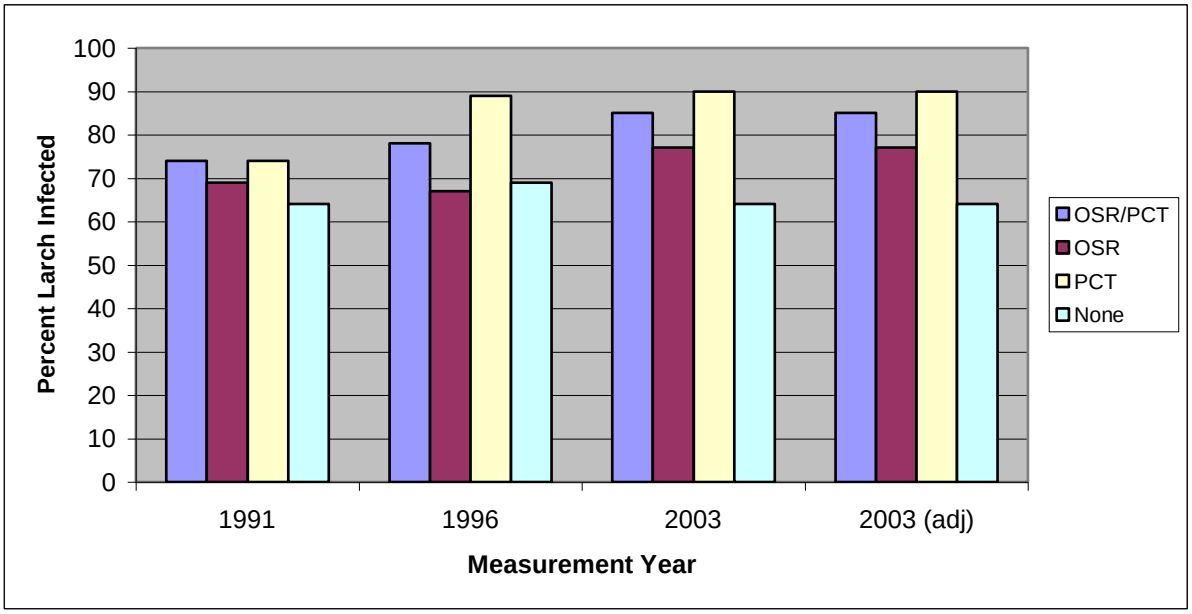

Figure 1. Infection in western larch by year and treatment. **OSR** = Overstory removal. **PCT** = Precommercial thin.

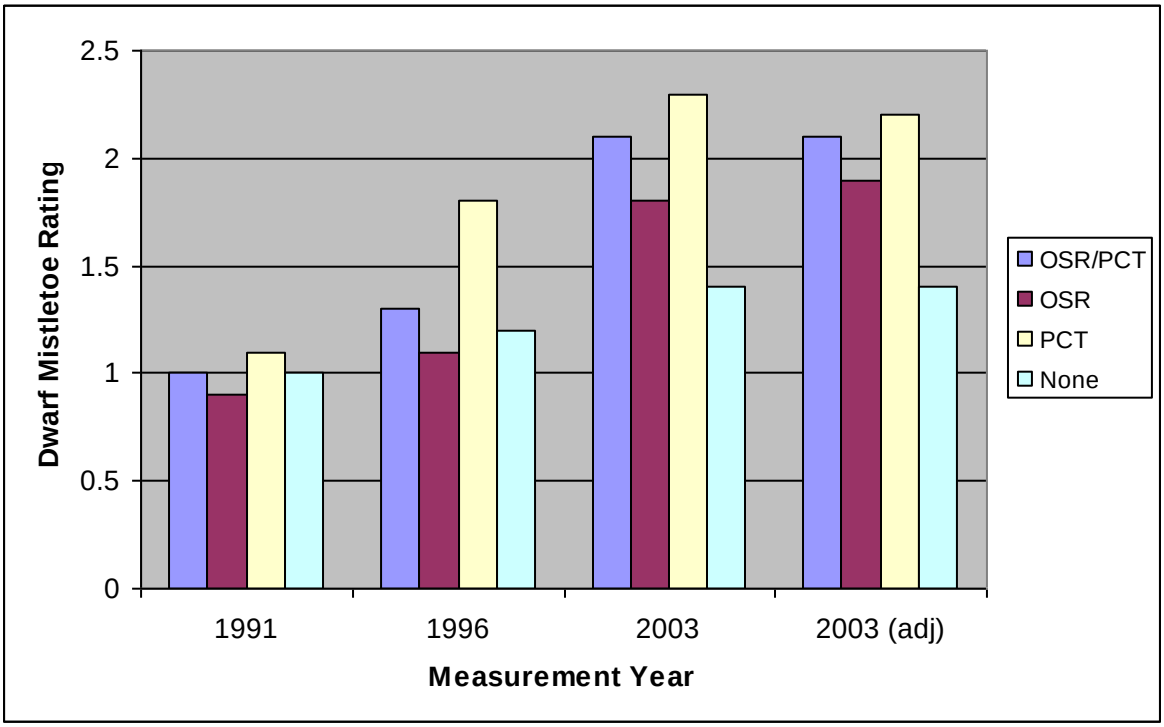

Figure 2. Hawksworth dwarf mistletoe rating of larch crop trees by year and treatment. **OSR** = Overstory removal. **PCT** = Precommercial thin.

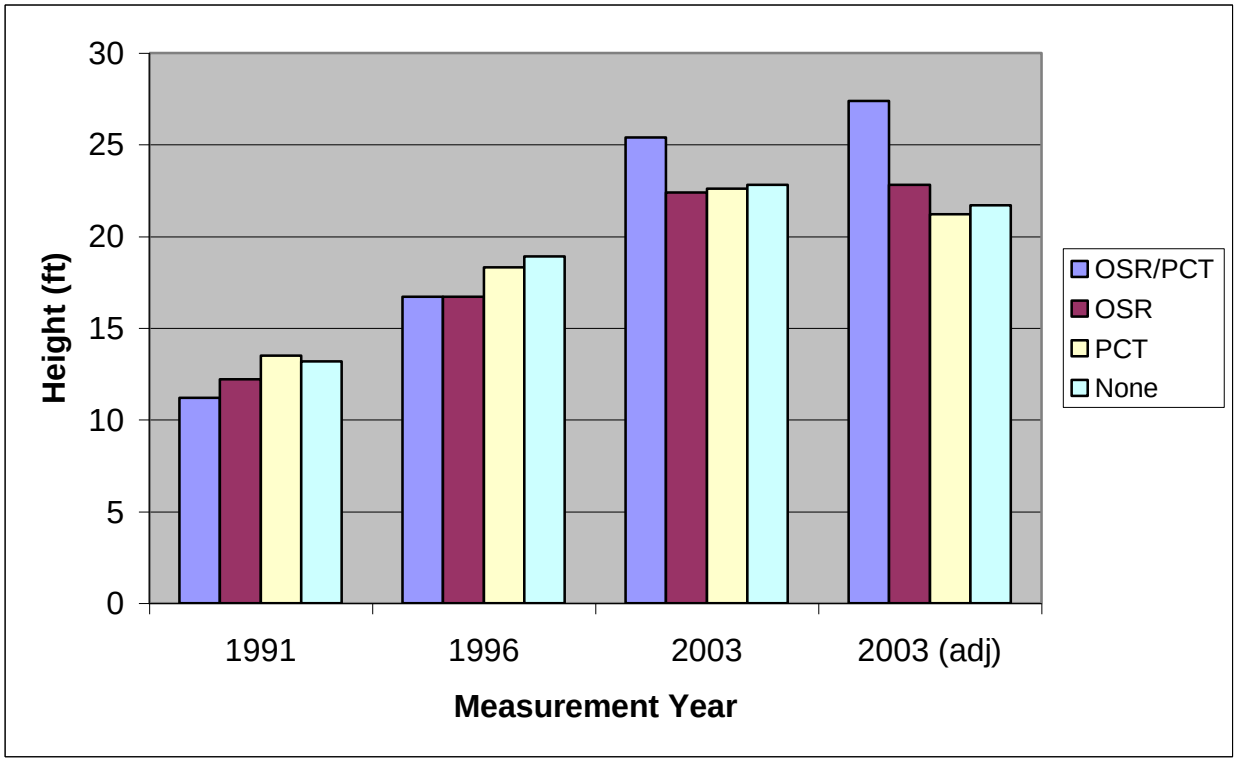

Figure 3. Height of larch crop trees by year and treatment. **OSR** = Overstory removal. **PCT** = Pre-commercial thin.

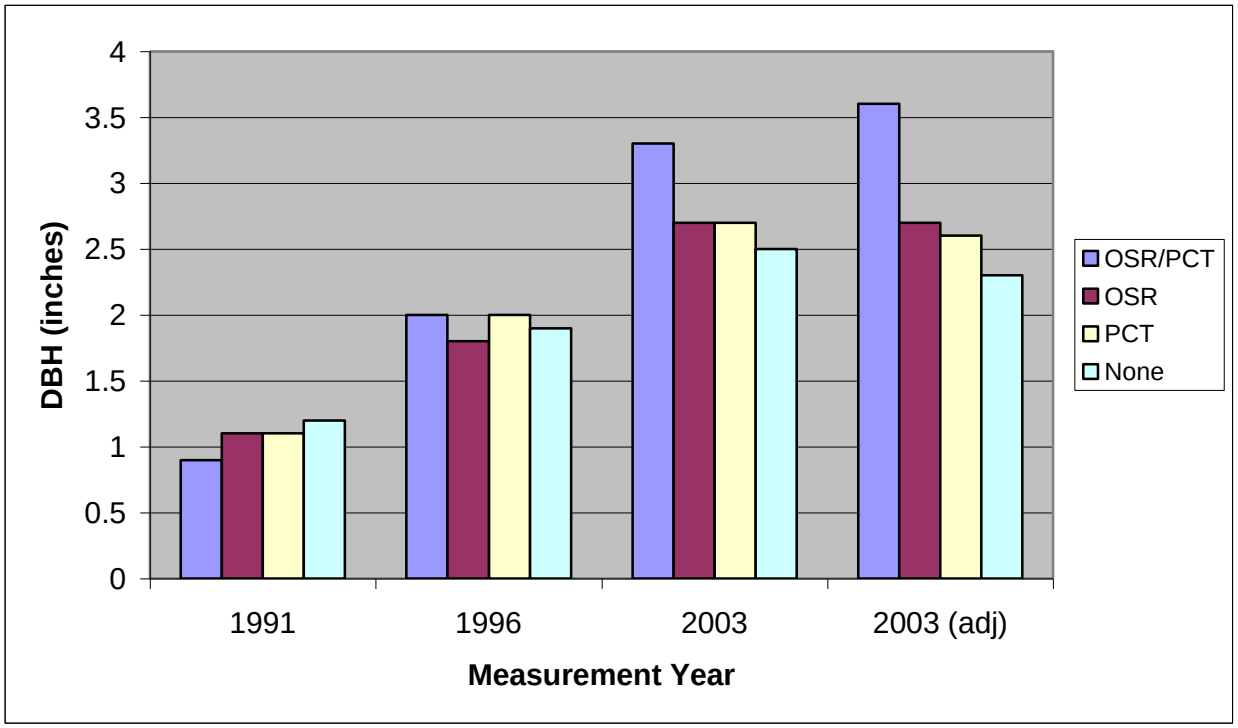

Figure 4. Diameter-at-breast-height of larch crop trees by year and treatment. **OSR** = Overstory removal. **PCT** = Precommercial thin.

Larch height and diameter growth were greater on the thinned plots receiving overstory removal compared to plots with no overstory removal (Figures 3 &4). Tree height on nonthinned plots with overstory removal was not significantly different than those on the other treatments; however, tree diameters on those plots were statistically equal to the plots without overstory removal and less than the thinned plots with overstory removal.

The larch regeneration was nearing 20 years of age by the time this project was initiated and treatments applied (Taylor et. al. 1993). Because this regeneration had developed under a larch overstory with DMRs of mostly 4-5, much of it was likely infected with dwarf mistletoe when treatments occurred. Mathiasen (1998) showed that most western larch regeneration developing under an infected overstory will itself be infected prior to age 14. Thinning and (or) overstory removal occurred in 3 of the 4 treatments, allowing infections to occur as barriers to mistletoe seed dispersal were removed. In addition, latent infections at the time treatments were applied were better able to grow as host vigor improved. Mistletoe spread is not evident in the nonthinned plots without overstory removal, most likely because the plots have remained relatively undisturbed.

Conclusion

Twelve years post-treatment the positive effects of overstory removal and thinning on individual crop tree growth, and the negative effects of increased dwarf mistletoe spread and intensification among thinned trees is evident. Results of the fifteen and twenty year data should clarify the impacts of these treatments on crop tree growth and spread and intensification of dwarf mistletoe.

References

Hawksworth, F. G. 1977. The 6-class dwarf mistletoe rating system. General Technical Report RM-48. USDA Forest Service Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 7p.

Mathiasen, R. L. 1998. Infection of young western larch by larch dwarf mistletoe in northern Idaho and western Montana. Western Journal of Applied Forestry 13:41-46.

Taylor, J., and Marsden, M. 1997. Permanent plots for studying the spread and intensification of larch dwarf mistletoe and the effects of the parasite on growth of infected western larch on the Flathead Indian Reservation, Montana: results from the 5-year re-measurement. FHP Report 97-2. USDA Forest Service Northern Region, Forest Health Protection, Missoula, Montana. 5p.

Taylor, J., Reedy, T., and Corse, T. 1993. Permanent plots for studying the spread and intensification of larch dwarf mistletoe and the effects of the parasite on growth of infected western larch on the Flathead Indian Reservation, Montana. FPM Report 93-2. USDA Forest Service Northern Region, Forest Health Management, Missoula, Montana. 13p.